SOCIETAL LIFE CYCLE ASSESSMENT

Application of a methodology for the social life cycle assessment of recycling systems in low income countries: three Peruvian case studies

Sandra Aparcana · Stefan Salhofer

Abstract

Purpose In a previous phase of this work, a methodology oriented towards social Life Cycle Assessment (sLCA) was developed to assess the social impact of formalised recycling systems in low income countries. To support this, a literature review of social impact assessment methodologies was carried out incorporating the social issues of both the informal and the implemented, formal recycling approaches. The goal of this study is to determine the feasibility of applying this methodology by assessing the current social impacts of three Peruvian recycling systems based on two formalisation approaches. A further goal is to identify and measure the social impacts of the formalisation procedures, thereby confirming or rebutting the expectations and forecasts of organisations (NGOs, Local Authorities, Ministries & Business) involved in the implementation.

Methods The methodology developed was applied to three Peruvian recycling systems which had been formalised using two different approaches. One approach utilizes co-operation with recyclers' associations and the second one, operated by the municipality uses formalised recyclers as employees. Interviews were conducted with local recycling system stakeholders in order to collect data to assess fulfilment of the social criteria. Three impact categories and 9 subcategories were analysed using 26 indicators. To transform the qualitative information into numerical values, a score system 1 or 0 for the fulfilment or non-fulfilment of social criteria was applied. After obtaining the indicators' average scores, further characterisation by social impact subcategory was effected. The final scores for the subcategories show the fulfilment or otherwise of all social criteria related to the subcategory.

Results and discussion The assessment substantiates similar negative impacts of both formalisation approaches for the social subcategories discrimination, recognised employment relationships and fulfilment of social benefit, physical working conditions and education. The formalisation based on cooperation with recyclers' associations reveals a positive social impact for freedom of association and collective bargaining, psychological working conditions and social acceptance whereas the method operated by the municipality scores better for working time and minimum, fair incomes. Regarding the methodology, no difficulties were detected in applying the indicators.

Conclusions It can be concluded that although sLCA was originally used to analyse products and production processes, it is feasible to adapt it for the social assessment of recycling systems based on formalisation of the informal sector in low income countries. A comparison of current social impacts between different formalisation approaches using this methodology is also viable. A further conclusion is that it is feasible to measure the social impacts of formalisation approaches using the selected indicators and characterisation procedure. Social issues such as anti-discrimination policies, employment terms, payment of social benefits, preventive policies, occupational and health training and adult education can be improved following the evaluation.

Keywords Developing countries · Formalisation · Recycling · Social impacts · Social indicators · Social life cycle assessment

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1 Introduction

The informal sector plays an important role in waste management systems in developing countries. It focuses mainly on recycling and therefore contributes significantly to the waste management of middle and low income countries. As a result, several cities in these countries have begun to recognise the economic, environmental and social contribution of the informal sector to waste management systems. Various cities in India, Peru, Brazil, the Philippines and Colombia have developed their recycling systems by formalising the informal sector and accommodating it in a waste management system (Rathi 2006; UN-HABITAT 2010; Gutberlet 2011; Wilson et al. 2009 and Medina 2000). Additionally, in some countries, e.g. Brazil, Colombia (Gutberlet 2011; Terraza and Sturzenegger 2010) and Peru (Peruvian 2009) national waste management legislation and waste management strategies have been implemented, aimed at a structured integration of informal recyclers into formal waste management activities.

On the other hand, common social problems within this sector still exist, for example inappropriate working conditions, child labour, discrimination, social rejection, etc. Frequently, it is children, pregnant women and socially excluded groups who work in informal recycling. Local and regional waste policies as well as non-profit organisations point to the implementation of formalisation approaches as an attempt to reduce or eliminate these social problems. Promoters of formalisation (NGOs, municipalities, government) assume that such problems stem from informal recycling and thereby expect formalisation to yield positive social impacts. These social impacts, however, have been not precisely measured and evaluated.

In a previous part of this research, a methodological approach for the social impacts assessment of recycling systems with formalisation approaches was developed, based on the social life cycle assessment methodology (sLCA) (SETAC Life Cycle Initiative 2009). The assessment of social impacts is a part of sustainability assessment, i.e. to consider environmental, economic and social impacts. While the first two have been established for years, no standard approach has yet been established for the social impacts addressed herein. The development of a methodological sLCA approach for recycling systems complements the sustainability assessment (together with Environmental Life Cycle Assessment und Life Cycle Costing). Hunkeler (2006) concludes that "…societal life cycle assessment provides a means to investigate how policy and policy makers can be linked to sustainable development…" and "…the goal of societal life cycle assessment is not to make decisions, but rather to point out tradeoffs to decision- or policy makers…". The sLCA UNEP guidelines of SETAC Life Cycle Initiative (2009) states that "… sLCA provides information on social and socioeconomic aspects for decision making, instigating dialogue on the social and socioeconomic aspects…". The methodology in this paper intends more to analyse the specific situation of formalisation approaches than to support the direct decision making process.

The present paper shows the application of this methodology in three Peruvian cities with recycling systems based on two different formalisation approaches. The feasibility of applying this methodology to evaluate social aspects is analysed. The relevance of social impact categories, subcategories, and indicators including their characterisation procedure are discussed. Similarities and differences regarding the social impacts, social weaknesses and the circumstances causing these results are compared and analysed. This study attempts to point out, what kind of social impacts exist by each formalisation approach. This in turn will provide more information regarding the fulfilment of the expectations held by decision makers.

2 Waste management and informal recycling in low income countries

Low income countries have some similarities regarding their socioeconomic conditions. In these countries, waste management systems are often not efficient and operate at low standards (Wilson et al. 2006). Scheinberg et al. (2006) defines waste management systems in low income countries as a "pre-modernised system based on a single disposal technology (dumping or landfilling). The waste management system is managed by a single major stakeholder: the local government sometimes supplemented by private waste collectors. Other actors—like recyclers—operate at the margins, and have the status of informal sector".

The shortcomings of waste management systems in low income countries can be demonstrated by the low national coverage rates. Gamarra and Salhofer (2007) submit examples of waste collection rates in Latin America (in Peru 74 %, Mexico 70 %, and Uruguay 71 % in terms of % waste collected) and compare them with the waste collection rates of Central Eastern Europe and Central Europe, which are nearly 100 %. The authors specify the use of controlled dumps, uncontrolled dumps and sanitary landfills as the most commonly used end disposal systems in Latin America. The presence of informal recycling is identified by uncontrolled and controlled dumps. This situation, along with the deficient collection rates, allows the participation of the informal recycling under inadequate and uncontrolled conditions. Figure 1 presents a flow diagram of a common waste management system in Peru including informal recycling, as an example. The material flow corresponding to recyclable waste (plastic, glass, metal, paper and cardboard) and residual waste (organic waste, non-recyclable waste materials, etc.) are indicated.

Fig. 1 Example of a typical waste management system in low income countries
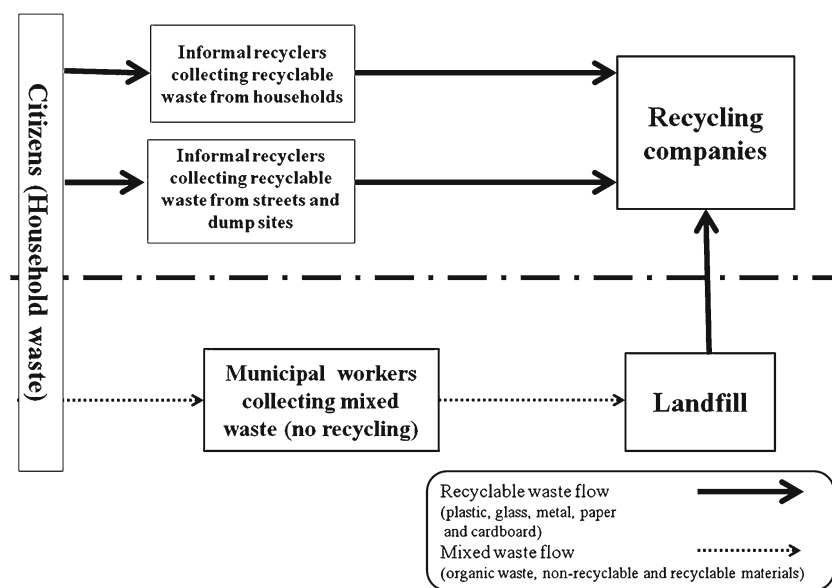
Informal recycling comprises individuals or groups that have no access to formal recycling activities. They are referred to by many names depending on the local language but they are usually known as scavengers, waste pickers or rag pickers (Medina 2000). Other authors prefer to designate them "recyclers" (Gutberlet 2011) in recognition of their recycling activities and their contribution to the recycling market in low income countries. For this work, "recycler" has been adopted.

Recyclers extract recyclable materials (plastic, glass, metal, paper and cardboard) from dumping places, street bins, communal collection sites, etc. and sell the goods in order to improve their livelihoods (Scheinberg et al. 2006). They perform their activities under poor working conditions which represent a high risk to their health and living conditions. Numerous studies have shown the presence of diseases related to working with waste (Medina 2000; Wilson et al. 2006; Zurbrügg and Schertenleib 1998). Further studies have identified other social problems: child labour, truancy in schools, incomplete school education for adults and poor working conditions (Medina 2000; Wilson et al. 2006; Scheinberg et al. 2006; International Labour 2004).

3 Formalisation approaches

Political trends and socioeconomic and environmental problems related to inefficient waste management have led to several low income countries attempts to modernise their systems in order to bring them up to European or American waste management standards (Scheinberg et al. 2006). This modernisation is characterised by the transformation to complex integrated systems, with multiple formal stakeholders, a wide diversity of technical operations and the expulsion or rejection of the informal sector (Scheinberg et al. 2006). Despite the "modernisation"

some cities have identified the need to recognise the contribution of the informal sector and its inclusion in formal waste management systems as an effective strategy. As a consequence, several formalisation approaches have been implemented in recent years, in order to improve waste management systems and to reduce the social problems of informal recyclers.

Medina (2000) describes some public policies that try to encourage informal recyclers to engage in other occupations in order to reduce their informal activities (Medina 2000). Scheinberg et al. (2006) indicate that this approach fails to recognise that leaving their recycling activities would precipitate a reduction in their incomes to below the minimum amount in these countries (Arroyo el al. 1998 cited by Scheinberg et al. 2006).

Further studies about formalisation in low income countries describe as main features the creation and support of recyclers' associations, their inclusion in formal waste collection, the creation of a legal framework to support their integration (Peru and Brazil), the improvement of working conditions, the improvement of income through cooperation contracts with local authorities, the elimination of child labour, educational programmes, diversification of services, etc. Strategies implemented in the Philippines, India, Colombia, Mexico, Brazil and Peru are based on these measures (Wilson et al. 2009; Rathi 2006; Medina 2000; Gutberlet 2011; Scheinberg et al. 2010). Figure 2 shows a flow chart of a commonly implemented formalisation approaches in low income countries.

4 Peruvian case studies

The Peruvian waste management system is regulated by the Peruvian Environmental Law and Peruvian Waste General

Fig. 2 Formalisation approach based on cooperation with recyclers´ associations
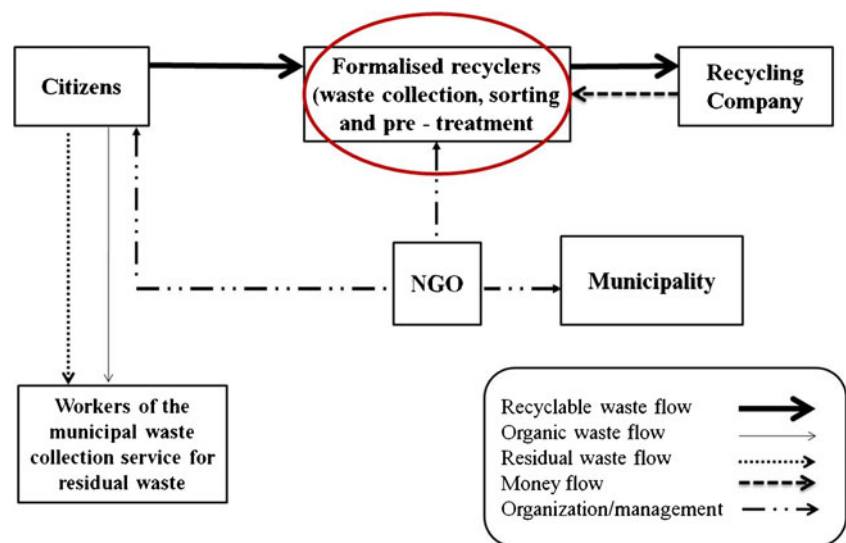
Law (MINAM Ministry of Environment 2011). Main stakeholders are the municipalities, the National Agency for Environmental Health, the Ministry of Environment (MINAM), households, businesses, industries, formal service providers and operators (e.g. private waste collectors, formal recycling industry) and informal recycling sector. In the average of Peru, approximately 70 % of waste is formally collected by municipalities, and the rest is collected by informal recyclers in streets, dumpsites, and diverse places (markets, restaurants, etc.). Municipal waste is collected and transported by compactor trucks, open trucks, dump trucks to transfer stations or directly to landfills. In some occasions the wastes are also transported to uncontrolled dumpsites (MINAM Ministry of Environment 2011).

Main activity of the informal sector in Peru is the recovery and valorisation of inorganic recyclables. Further the informal sector sometimes provides an informal collection service in poor areas that are not covered by formal waste collection. Typically, informal waste collectors use tricycles to collect mixed waste in areas characterised by poor maintenance of roads. The collection and recovery of recyclables takes place in streets, in dumpsites, in transfer stations and in landfills. The inorganic recyclables go to junkshops that pack, process, and sell the material to recycling end-users, or to industries. The organic wastes are informally collected from restaurants and markets and then transported to piggeries (NGO 2010).

The study for testing the developed methodology was conducted in three Peruvian cities: San Vicente de Cañete, the Colca Valley, and Santiago de Surco. It should be made clear that this assessment was carried out by comparing only the households currently involved in the recycling systems of the three cities. As the assessment is related to the recycling services, a household located in Vicente de Cañete is comparable with a household in the Colca Valley and Santiago de Surco and vice versa.

San Vicente de Cañete, located in Lima, Peru has a recycling system with a formalisation approach based on cooperation with recyclers' associations. It was developed by an initiative between the local NGO IPES and formalised recyclers. It has a collection rate of 15 % (15 % of households of the city participate in the recycling system) (UN-HABITAT, 2010). The second case study with a recycling system based on the same formalised approach is the Colca Valley located in Arequipa, Peru. The Colca Valley has 19 districts and 5 of them (Callalli, Yanque, Lari, Madrigal, Chivay) are involved in the recycling system, having a collection rate of 10 % (10 % of households of the city participate in the recycling system) (DESCO 2011). In this case, the drive to create a recycling system based on formalised recyclers came from the local NGO DESCO which worked together with informal recyclers, formalising them by organising recyclers' associations. The third case study pertains to Santiago de Surco, located in central eastern Lima, Peru. This district has a recycling system managed and operated by the municipality without the participation of organised recyclers as in the last two cities and it has a collection rate of 38 % (38 % of households of the city participate in the recycling system). The recycling system was founded and implemented with, exclusively, the support of the municipality (Municipality of Santiago de Surco 2011)

The formalisation approach based on cooperation with recyclers' associations (case study Colca Valley and San Vicente de Cañete) has three main stakeholders who cooperated on the implementation and operation of the system: the municipality, a Non-Governmental Organisation (NGO) and the recyclers' association (former informal recyclers). While the NGO develops the project and finances the first steps of its implementation, the municipality authorizes the access of the recyclers to the households and permits the formal collection of recyclable materials. The formalised recyclers collect the recyclable materials (glass, paper, cardboard, metal and plastics) from

households without paying for them. They then transport the collected waste by tricycle and subsequently perform a more thorough, manual sift at tables in sorting centres. After this separation the recyclable materials are sold on the local recycling market. With this approach, the income of the recyclers depends not only on the price and quantity of materials sold, but also on the number of participating citizens. Measures were taken in order to improve the working conditions of the recyclers, i.e. campaigns to raise the awareness and identification of the population with the recyclers, vaccination campaigns, and recyclers' access to health prevention and working equipment.

In contrast, the city of Santiago de Surco has a recycling system operated entirely by the municipality. As the only stakeholder, the municipality has employed the recyclers as formal workers at the municipal recycling plant. The workers collect recyclable materials (glass, paper, cardboard, metal and plastics) door to door without paying any revenue to the households. The collected waste is transported with waste collection trucks and the material is taken in by other workers at the municipal recycling plant. They separate more accurately than by using a sorting system with conveyor belts. The workers receive a fixed income independent of the amounts of materials sold. The entire system is financed by the municipality. Access to adequate working equipment and to health and social insurance are some of the measures for improving the working conditions of the municipal workers. Table 1 provides general information about the three case studies representing the two formalisation approaches. Figure 2 (a typical formalisation approach based on cooperation with recyclers' associations) shows the recycling systems in Colca Valley and San Vicente de Cañete and Fig. 3 the flow chart of the recycling systems in Santiago de Surco.

5 Methodology for social impact assessment of recycling systems based on formalisation approaches

The methodological approach was developed in a previous phase of this work (Aparcana and Salhofer 2013). This methodology is based on the sLCA framework developed by SETAC Life Cycle Initiative (2009). The terms in this paper correspond with definitions in the UNEP-SETAC Guidelines.

The procedure developed has been tested by applying it for the social assessment of three Peruvian recycling systems. One goal is the determination of current social impacts related to formalised recyclers involved in recycling systems with formalisation approaches. A further goal is to identify and measure the social impacts of the formalisation approaches themselves; thereby confirming, or refuting those impacts expected/forecast by organisations (NGOs, Local Authorities, Ministries & Business) involved in the implementation of the systems.

The structure of waste management systems in low income countries work similarly, having the same stages from waste collection to recycling and final disposal. The stakeholders involved in these activities are also similar: recyclers, municipalities, citizens, recycling companies (see Fig. 1). Taking that into account, this study considers a waste management system as a process formed of several phases, where the recyclers are affected to various degrees regarding their working conditions, health and human rights (see chapter 2 and chapter 3). Different formalisation approaches have different social impacts but all relate to the same social issues. This study assesses the social impacts of formalisation approaches on formalised recyclers.

Through this methodology, the social impacts related to the social impact categories of human rights, working conditions and socioeconomic repercussions as well as the potential for social improvement were identified, measured and compared among the case studies. These three impact categories are subdivided into 9 social impact subcategories, which are analysed through 26 semi-quantitative indicators.

The life cycle inventory for the three case studies was accomplished through interviews with the main stakeholders involved in the formalisation approaches (municipalities, recyclers' associations and NGOs) in September 2011. These interviews not only provided information about the social impacts, but also about the context thereof. The stakeholders interviewed could furnish details related to the context of recycling systems that were pertinent to the assessment results.

A check list of 56 open and closed ended questions used to collect the relevant information for the assessment of the social impact categories and their subcategories. The same check list was applied to all stakeholders with exception of the data collection for the subcategory psychological working conditions. In this case, the interviews were carried out only with the formalised recyclers. They could deliver more direct and reliable information regarding this impact subcategory, because it is mainly related to their work satisfaction level.

Currently, there is no consensus about the characterisation method for the social impacts. The UNEP-SETAC Life Cycle Initiative (2009) asserts that a scoring system can be used in order to evaluate and interpret the social data. Studies about different approaches for social impact assessment propose the application of scores, e.g. + or − (Brouwer and Van Ek 2004), 1 to 5 (Klang et al. 2003; Kijak and Moy 2004) and the interpretation of results are based on a comparison with international or local social regulations, e.g. Klang et al. 2003 for the social evaluation of management of demolition waste. Dreyer et al. (2010) developed a characterisation methodology oriented towards a preventive approach that assesses social management measures and also uses an elaborated scoring system. The method proposed by Ciroth and Franze (2011) calls for expert judgement for a

Table 1 Case studies description

City	Formalisation approach	Stakeholders	Collection rate of recycling system (% of household participating in the recycling system)	Collected materials	Number of workers	Hiring strategy	Income	Presence of informal recyclers outside the assessed recycling system
San Vicente de Cañete Colca Valley	Cooperation with recyclers' associations	NGO, formalised recyclers and municipality	15 % 10 %	Glass, plastics, paper and cardboard and metals	6 14	Cooperation agreement among the municipality and association of recyclers permitting the access to households and the collection of recyclable materials	Variable income based on the amounts of recyclable material sold	Yes (unknown quantity)
Santiago de Surco	Operated by the municipality with recyclers as formal workers	Municipality and recyclers at the recycling plant	38 %		35 (at the recycling plant)	Recyclers at the recycling plant have working contracts as formal employees with the municipality	fixed income	

subjective score assignment of 1 to 5 and for the interpretation of social impacts.

Spillemaeckers et al. (2001) develop a characterisation approach based on semi-quantitative indicators and the application of the scores 1 and 0 corresponding the fulfilment or non-fulfilment of the social criteria (international or local social conventions). The average of the scores for each impact subcategory is then calculated. This approach is also angled towards the assessment of human rights and working conditions. In a similar vein, Spillemaeckers et al. (2001) and Foolmaun and Ramjeeawon (2013) developed an sLCA approach for used PET bottles, where the data was obtained through surveys involving yes or no type questions. The authors converted qualitative inventory data and aggregated it using a score system with two steps: conversion of inventory results (indicators) into percentages, e.g. the number of workers answering yes to wage satisfaction in the survey is converted into a percentage (e.g. 55 % are satisfied with their wage) and assigned scores from 0 (very bad) to 4 (very good) to indicators and subcategories (e.g. a score 2 corresponds to 55 %). For sub-categories with more than one indicator, similar scores ranging from 0 to 4 were used for each indicator. The score for the subcategory was the average of their indicator scores Foolmaun and Ramjeeawon (2013). The authors applied the same weight for all subcategories and their indicators as with the other approaches described.

The characterisation procedure for this methodology proposes the application of a score system for each indicator and assigns the values 1 and 0 for the fulfilment or non-fulfilment of the social compliance criteria. The answers given by each stakeholder interviewed have been converted into these values. Because several stakeholders were interviewed, the average score for each indicator was calculated.

$$\frac{\sum_{i=0}^{n} Si}{n}$$

Eq. 1: calculation of average score
Si = Score for indicator i given by the stakeholder i
n = number of interviewed stakeholders

The result is an average, decimal score between 0 and 1 for each indicator (26 in total). The average score calculated for each indicator represents the proportion of stakeholders (as a percentage) affirming fulfilment of the social criterion. At least 50 % of the stakeholders interviewed (0.5 average score) have to report the fulfilment of the social criterion in order to consider this result reliable. In this case, the social criterion is considered fulfilled and the average score is rounded up to 1.

When the average score is less than 0.5, it signifies that less than 50 % of the interviewees reported fulfilment of the evaluated criterion and the score is rounded down to 0.

Fig. 3 Flow chart recycling system with formalisation in Santiago de Surco
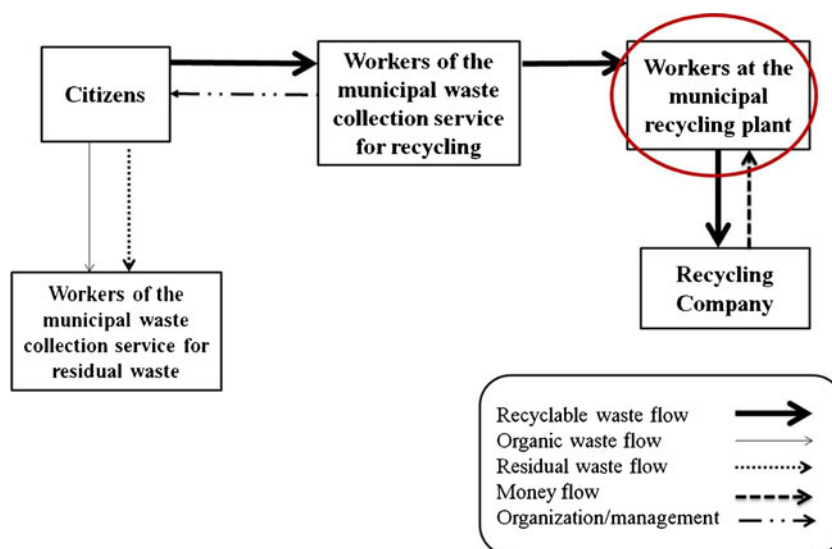
As mentioned above, only recyclers were interviewed regarding the indicators for the impact subcategory psychological working condition. The score assignation and fulfilment criteria were defined differently for the indicators of both impact subcategories. A scale of 1 (very bad), 2 (bad), 3 (medium), 4 (good) and 5 (very good) denoted degrees of satisfaction. In order to transform the scores obtained to a scale similar to that of the indicators in other subcategories (0 or 1), the following values were also assigned: 0, 0.25, 0.5, 0.75 and 1 for the scale 1, 2, 3, 4 and 5, respectively. An average of the scores given by the recyclers has been calculated. An average score higher than "medium" (0.5) connotes fulfilment of the social criterion for the indicator and it receives the final score "1". An average score lower than or equal to 0.5 means non-fulfilment of the social criterion and the final score "0" is assigned. The reason for applying a different scale for the impact subcategory psychological working conditions was the subjective evaluation of the recyclers about their own satisfaction levels. It was difficult for them to categorise their satisfaction feelings in only 2 levels "yes, I am satisfied" (score 1) and "no, I am not satisfied" (0). In the case of the data collection for the other social subcategories, the information is fact based (e.g. use of uniforms, presence of training programmes, etc.) and fulfilment can be evaluated with "yes, there is…, yes, we have it" or "no, we do not have it… no, there is not". However, for the psychological working conditions, the recyclers understood the 1 to 5 scale better and showed more willingness to elaborate on their answers.

After obtaining the average scores of the 26 indicators the score for each subcategory was calculated and interpreted as follows: when all the indicators within a subcategory obtain the score "1", the subcategory obtains the overall evaluation "1" meaning the fulfilment of all the social criteria for the subcategory. In the case that one or more indicators within a subcategory receive "0", the subcategory also obtains the

overall evaluation of "0" meaning the non-fulfilment of the social criteria related to the subcategory. The reason for this interpretation is that each indicator within a subcategory represents a basic social aspect to be fulfilled in accordance with social regulations. In order to obtain a positive subcategory evaluation all of the indicators within it have to be evaluated with "1". The principle of choosing severe evaluation criteria for the results at subcategory level was also applied by Ekener-Petersen and Finnveden (2013).

It is important to mention that although this evaluation is based on scores, these results are not relevant as numeric values. The aim is to show the differences between the case studies in terms of their social aspects. The results indicate which aspects of a formalisation approach are favourable or not.

6 Results and discussion

6.1 Characterisation results

Table 2 shows the results of the social impact assessment for the indicator and subcategory levels respectively. The three recycling systems correspond to formalisation approaches described in chapter 2.

6.2 Indicators relevance and applicability of the characterisation procedure

Previous studies mention the use of direct and indirect indicators to measure the phenomenon that cause a social impact. Direct indicators are defined as traditional, quantitative and one-dimensional representations of a social impact, e.g. "number of employees under 15 years old" (Jørgensen et al. 2008; Dreyer et al. 2006). Indirect indicators aim to assess the preventive management efforts of the

Table 2 Results of the social assessment at indicators and sub category level

Social impact category	Social impact subcategory	Indicator	Results at indicator level			Results at sub category level	
			Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)		Formalisation approach (operated by the municipality)	Formalisation approach (cooperation with recyclers' associations)
			Recycling system Santiago de Surco	Recycling system San Vicente de Cañete	Recycling system Colca Valley	Recycling system Santiago de Surco	Recycling systems San Vicente de Cañete and Colca Valley
Human rights	Child labour	No child labour	1	1	1	1	1
	Discrimination	Formal policy against discrimination	0	0	0	0	0
		No income differences between women and men	1	1	1		
	Freedom for association and collective bargaining	Presence of collective bargaining	0	1	1	0	1
Working Conditions	Working hours	Fulfilment of overtime agreed in working contracts	1	0	0	1	0
	Minimum income, faire income	Average income according to legal framework	1	0	0	1	0
		Absence of non-agreed wage deductions	1	1	1		
		Regular payment for the workers	1	1	1		
		Minimum income according to legal framework	1	0	0		
	Recognised employment relationships and fulfilment of legal social benefits	Existence of legal working contracts for all workers	1	1	1	0	0
		Access to legal social benefits	0	0	0		
		Access to further social support programmes for workers	0	0	0		
	Physical working conditions	Absence of work accidents	0	1	0	0	0
		Formal policy about occupational health and safety	0	0	0		
		Vaccination for workers	1	1	1		
		Training programmes for workers regarding occupational health and safety	0	0	0		
		Access to preventive health care programme for workers	0	1	1		
		Presence of medical equipment at the working place for the workers' use	1	0	1		
		Absence of diseases related to waste handling	0	0	1		
		Appropriate working equipment	1	1	1		
	Psychological working conditions	Willingness to continue working in the same company or sector	0	1	1	0	1
		Work satisfaction	1	1	1		

Table 2 (continued)

Social impact category	Social impact subcategory	Indicator	Results at indicator level			Results at sub category level	
			Formalisation approach (operated by the municipality) Recycling system Santiago de Surco	Formalisation approach (cooperation with recyclers' associations) Recycling system San Vicente de Cañete	Recycling system Colca Valley	Formalisation approach (operated by the municipality) Recycling system Santiago de Surco	Formalisation approach (cooperation with recyclers' associations) Recycling systems San Vicente de Cañete and Colca Valley
		Willingness to be trained regarding the work activities					
	Education	Educational level of children from recyclers' families	1	1	1		
		No school absence of children from recyclers' families	1	1	1		
Socioeconomic repercussions		Existence of educational programmes for self-development	0	0	0	0	0

company rather than the reported impacts (Jørgensen et al. 2008); e.g. presence of management measures ensuring the training of workers in relation of safety and occupational work, instructions for the safe use of machines, etc. (Dreyer et al. 2010).

As previously asserted, some social impacts can be better evaluated by using indirect indicators, which are based on preventive social policies. The findings of this study support this perspective for the assessment of working conditions. The absence of a formal policy to ensure appropriate health and security at work seems to negatively affect further social aspects like work accidents and cases of disease caused by the contact with waste. A social assessment employing indirect indicators can complement one made using direct indicators by showing more clearly the weaknesses of a formalisation approach. Indirect indicators are able to detect possible flaws based on the presence or absence of preventive social policies without analysing information given directly by the stakeholders.

Regarding the semi-quantitative characteristic of the indicators, diverse studies (Jørgensen et al. 2008; Spillemaeckers et al. 2001, UNEP-SETAC Life Cycle Initiative 2009 and Dreyer et al. 2006) verify the ability of these indicators to measure and describe qualitative information through numerical units. As a result of this study it can be asserted that social impacts on formalised recyclers can be expressed by applying score systems. The data collected through interviews with the stakeholders of recycling systems can be easily transformed into numerical information. That allows the characterisation and the direct comparison of social impacts between recycling systems. It also allows the clear identification of their social weaknesses, similarities and differences.

No difficulties were encountered during the data collection steps, characterisation and comparison of results. The information collected through the interviews about the fulfilment of social criteria was transformed into scores. The calculation of indicators' average scores, rounding up and down, and interpretation was easily accomplished, and reflects both positive and negative social impacts of the assessed recycling systems.

6.3 Social impact interpretation of the case studies

The methodology developed was tested in two different formalisation approaches implemented in three Peruvian recycling systems. The aim was to determine the feasibility and applicability of this methodology for assessing the contribution of formalised recycling systems in terms of social impacts, compared to recycling systems based on informal recyclers. In chapters 2 and 3, the social problems of informal recyclers in low income countries were described. Substandard working conditions, discrimination, child labour, poverty, poor health conditions, lack of

education, and low work satisfaction are some of the social problems commonly identified. The two formalisation approaches were analysed and compared, in order to determine their differences regarding social impacts. For this study, it is assumed that a recycling system without formalisation (based on informal recyclers) does not fulfil any of the social criteria of this methodology and scores 0.

In order to perform this assessment, the functional unit is defined as the amount of household recyclable waste collected by one house during 1 year. Based on the Peruvian national average waste generation rate and waste composition rate (see MINAM Ministry of Environment 2011), the functional unit amounts to 60 kg/inhabitant-year of collected recyclable household waste.

In low income countries, the collection of recyclable waste can be carried out by the municipality, informal recyclers or formalised recyclers. The definition of a functional unit allows the application of the methodology to different recycling systems. The recycling activities that are considered for the analysis are the recyclable waste collection and manual pre processing.

6.4 Human working rights

The results of this study reveal that both formalisation approaches did not show any differences regarding their social impacts for the social subcategories child labour and discrimination. Both were positively and negatively evaluated, respectively. An explanation for this result might be that Peruvian social regulations for the formal labour market strictly limit the working activities of those less than 18 years old. The formalisation approaches assessed have sought to fulfil this legal social criterion. With regard to the subcategory discrimination, both formalisation approaches obtained a negative evaluation. Although they showed no differences between women's and men's incomes (meaning fulfilment of the indicator), they acquired a negative evaluation because of the absence of formal policies to ensure equal opportunities and rights.

In respect of freedom of association and collective bargaining, the formalisation approach based on cooperation with recyclers' associations fulfilled the social criterion and received a positive evaluation. In stark contrast, the formalisation approach operated by the municipality did not fulfil the social criterion and scored negatively. The main reason for this result is the absence of periodic or scheduled meetings between the municipality and the recyclers (workers at the municipal recycling plant) as an organised group. No coordination or negotiation activities were reported during the interviews. In the case of the formalisation approach based on cooperation with recyclers' associations, consultations between recyclers and other stakeholders were mentioned as a regularly activity.

6.5 Working conditions

For both formalisation approaches, the assessment did not reveal important differences in the following subcategories: recognised employment relationships and fulfilment of legal social benefits and physical working conditions. In relation to the first, although both approaches have legal employment contracts with the recyclers, they obtained a negative evaluation for this subcategory. The reason is that none of them give the recyclers full access to legal social security and social benefits such as retirement pension or family health programmes. In the case of the formalisation approach operated by the municipality, this can be explained by the short term contracts given to some of the recyclers. This type of working contract does not allow full access to social security programmes. The formalisation approach based on cooperation with recyclers' associations works on the basis of participation agreements between them and the municipality. The associations and their members assume responsibility for their subscription to social programmes but they are not compelled to fulfil this duty and they are not scrutinised by the municipality or any other authority. They apparently have no awareness of the importance of securing these social benefits and do not sign up for them.

Neither formalisation approach fulfilled of all social indicators within the subcategory physical working conditions. An interesting exception is the result from the indicator: access of workers to preventive health programmes. Here, the formalisation approach based on cooperation with recyclers' associations gained a positive evaluation in contrast to the formalisation approach operated by the municipality, which was negative. In the first example the study detected meaningful support from NGOs working for the implementation of the formalisation, in providing recyclers with access to health prevention programmes (access to private health insurance with funding from the sale of recyclable materials or government health programmes for people in extreme poverty, etc.). It seems that the NGOs take the recyclers' need for these programmes strongly into account. In the case of the formalisation approach operated by the municipality, not all workers have access to health programmes. An explanation is the presence of short term contracts, which do not cover the costs of health programmes for the workers, who themselves are not able to assume these costs.

It should be mentioned that absence of a formal policy for occupational health and safety could have a negative effect on working conditions in the two formalisation approaches. This lack of preventive policies is manifested in the case studies evaluated by the incidence of work accidents and diseases caused by contact with waste. This finding supports the assertion that the implementation of preventive measures and social policies can ensure a positive social impact of the

formalisation approaches regarding physical working conditions.

Significant differences were identified for the subcategories working hours, minimum and fair incomes and psychological working conditions. During the interviews it was noted that no overtime was paid to recyclers in the formalisation approach based on cooperation with recyclers' associations. Although working times were initially agreed and essentially fixed, the recyclers currently work longer hours. For this reason the formalisation approach was negatively evaluated. The recyclers' income depends directly on the market prices and the amount of recyclable materials collected and sold. Price or quantity downturns mean the recyclers have to work longer to reach an adequate income. In contrast to this situation, it was observed that the recyclers from the system operated by the municipality usually work the hours agreed in their working contracts. The reason for that is their fixed payment, which does not depend on the market prices or amounts of waste material. The recyclers' income is not influenced by negative conditions (market or collected waste amounts).

The results described in the social subcategory working time have a strong correlation with the following impact subcategory: minimum income and fair income. In this subcategory, the formalisation approach operated by the municipality showed also better results than the formalisation approach based on cooperation with recyclers' associations. The first received positive evaluations for the four indicators within this subcategory. The second, however, was negative evaluated on the indicators related to average and minimum income. This result can be explained by the fact that associated recyclers often face sharp fluctuations in prices and recyclable waste amounts (sometimes citizens do not separate their wastes or do not give them to the recyclers). This reduces their incomes which then do not reach the legal minimum or average wage. In the case of the formalisation approach operated by the municipality, incomes are fixed and are not influenced by such fluctuations.

It is interesting to note the results obtained for the social subcategory psychological working conditions. Although the recyclers at the municipal recycling plant receive higher incomes, reaching the legal minimum and the average incomes for the sector, the overall evaluation for this subcategory was negative. Less work satisfaction was found and less willingness to continue working in the same recycling activities than in the case of the formalisation approach based on cooperation with recyclers' associations. A possible explanation for this might be that the associated recyclers are happy with the improvement of their working conditions in comparison with their previous working situation (working at waste dumps and on the street). Additionally, the associated recyclers, who also perform the door-to-door collection, reported satisfaction in the recognition of their work by residents and other stakeholders, their contribution to environment protection and their feeling of having a share in a better world.

In contrast with the recyclers from the formalisation approach based on cooperation with recyclers' associations, the recyclers from the formalisation approach operated by the municipality do not have any contact with the members of the public during their work. No direct feedback from citizens about the recognition of their recycling activities exists. For this reason, they are not psychologically motivated to contribute to environmental improvement. This would also negatively influence work satisfaction.

6.6 Socioeconomic repercussions

One subcategory was evaluated within this social category: education. Both formalisation approaches received negative evaluations in the subcategory access to education. This was caused by the lack of adult training for the recyclers, meaning the absence of adult education programmes for supporting or encouraging self-development. The promotion of self-development is important not only because of its positive impact on work satisfaction but also because of the possibility of improving the recycling business and of increasing access to new economic sources through gaining useful knowledge. Regarding the indicators educational level and no school absence of children of recyclers' families, both formalisation approaches were positive evaluated.

A limitation of this study was the evaluation based only on the reliability of the stakeholders' answers. A way to balance the answers given by individual stakeholders was the application of a score system and the calculation of average scores. It is recommended using and including local reports or studies in the evaluation where possible. The information from these documents would counterbalance the reliability of stakeholders' answers. For the social assessment, the inclusion of more management indicators is recommended. They should be based on preventive social policies in order to more accurately evaluate the current social impacts of a recycling system.

7 Conclusions and recommendations

It is concluded from this study that although the sLCA is normally used for the assessment of products and production chains, it is feasible to apply this methodology to the social assessment and comparison of recycling systems based on formalisation approaches. The adopted indicators and the characterisation procedures facilitate the assessment and interpretation of the selected impact categories and subcategories. In relation to the indicators, it can be concluded that the use of indirect indicators based on preventive social

policies is feasible for assessing current social impacts of recycling systems. It is also concluded that the social weaknesses of formalisation approaches as well as their positive aspects can be identified through the application of semi-quantitative indicators.

Regarding the social impacts of formalisation approaches, the one based on cooperation with recyclers' associations achieves positive social impacts in the subcategories freedom of association and collective bargaining, psychological working conditions, while the formalisation approach operated by the municipality shows positive social impacts in the subcategories working hours and minimum and fair wages. The assessment displays similar results for both approaches regarding child labour. Negative social impacts for discrimination, recognised employment relationships and fulfilment of social benefits, physical working conditions and education were identified for both formalisation approaches. These aspects need to be improved by both formalisation approaches.

Regarding the income of recyclers, the study shows the need to stabilise payments in the formalisation approach based on cooperation with recyclers' associations, the aim being the reduction of negative influences of price and waste amount fluctuations.

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